

Comments on “Validation of an accelerometer-based method to measure the use of manual wheelchairs” by Sonenblum et al. Med Eng Phys 2012; 34(6):781–6

Coulter, Elaine H.; Dall, Philippa; Rochester, Lynn; Hasler, Jon; Granat, Malcolm

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re: validation of an accelerometer-based method to measure the use of manual wheelchairs

We were surprised in this article by Sonenblum et al at the lack of comparison with previously published work. We have previously validated this technique [1] using a tri-axial accelerometer attached to the wheel of the wheelchair, and processing the data in an almost identical manner to that of Sonenblum et al, except with regard to smoothing the signal. We used change in angle between successive sampling points to indicate movement, and then smoothed the signal by defining a minimum duration of 1s for movement and non-movement periods. We validated this technique using data from 14 individuals with spinal cord injury who were all regular wheelchair users. Participants wheeled around an indoor circuit (22m), and an outdoor course (including 2x ramps, 2x obstacle manoeuvres with turns). Outcomes of duration of movement and number of wheel revolutions (directly related to distance) were compared to video. The monitoring system demonstrated excellent validity for wheel revolutions ($ICC(2,1) > 0.999$) and duration of movement ($ICC(2,1) 0.981$). Differences between the wheelchair monitoring system and rater were 1.87s (mean) and 7.15s (maximum) for duration of movement, and 0.002 (mean) and 0.038 (maximum) for wheel revolutions (equivalent to over-ground distances of 0.4cm and 7.2cm in a manual wheelchair). Bland-Altman plots showed that the monitoring system tended to overestimate duration of movement, but no tendency to over- or under-estimation for the other outcomes.

Sonenblum et al validated their system in three segments, with 2 or 3 individuals per segment, using regular wheelchair users in only one segment, and reported mean percentage accuracy for each segment. Direct comparison of the two validation studies requires conversion between percentage and absolute error, which we have presented here based on the reported duration and distance of the validation segments. We excluded data from the segment for kerbs and gravel path as only one participant completed this segment. In our study, accuracy was consistent across the range of duration and distances used, meaning that percentage accuracy reflected the duration of the segment rather than error in measurement. Our mean percentage accuracy of duration ranged from 96% for the longest segment (42s) to 84% for an 11s segment. All of the segments in the Sonenblum et al validation were of longer duration than ours, but demonstrated larger absolute duration of errors of 4.9s, 5.8s, and 38s. In our study, converting the maximum difference in distance travelled yielded percentage accuracies over 98% for each segment (between 5m and 42m long). The mean absolute error of the single 23m segment used for distance by Sonenblum et al was 92cm, compared to a maximum error of 5cm in a 22m segment in our validation protocol. Therefore, for the validation data provided, we suggest that our method of converting tri-axial acceleration, compared to that of Sonenblum et al, is marginally better for calculation of duration of movement, and significantly better for calculating distance. Without this comparison it is not possible to assess the merit of the Sonenblum approach, over and above what is already known.

[1] Coulter EH, Dall PM, Rochester L, Hasler JP, Granat MH. Development and validation of a physical activity monitor for use on a wheelchair. *Spinal Cord* 2011; 49:445-50.